COSTS AND BENEFITS OF RELAXING INTERNATIONAL FREQUENCY HARMONISATION AND RADIO STANDARDS

FINAL REPORT

SUMMARY

INDEPEN AND AEGIS SYSTEMS

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Summary

• Scope of study

1. This is the final report of a study for Ofcom to assess the costs and benefits of relaxing European measures for frequency harmonisation and equipment standardisation. The key issues addressed are:

    - What are the potential economic benefits and costs of European harmonisation and standardisation measures?
    - What factors affect the scale of costs and benefits of relaxing European harmonisation and standardisation measures?
    - What are the interference effects of relaxing radio standards and frequency harmonisation?
    - How might the costs and benefits of relaxing harmonisation and standardisation measures be quantified?

2. The European harmonisation measures referred to in this report comprise European Community (EC) Directives and Decisions or Recommendations of the European Conference of Postal and Telecommunications Administrations (CEPT). EC Directives have the force of law whereas countries have discretion over whether they sign up to CEPT measures. Standardisation is undertaken at a European level through the European Telecommunications Standards Institute (ETSI). Adoption of ETSI standards is voluntary though elements of the standards are sometimes written into harmonisation measures, in which case they may become mandatory.

3. This study is related to other Ofcom initiatives.

    - The Autonomy Study: this study assesses the extent to which spectrum use in the UK is constrained by interference to or from neighbouring countries. The results of this study are used in our analysis.
    - The Ofcom initiative on spectrum trading: harmonisation and standardisation measures are fundamental to the definition of property rights and may constrain the potential for trading. They therefore have an impact on the economic value which can flow from spectrum trading.
    - A study for the Radiocommunications Agency (RA) of administered incentive pricing for radio spectrum: relaxation of harmonisation and standardisation measures could give more opportunities to change the use of spectrum in response to pricing, and could change calculated administered incentive prices if the set of potential alternative spectrum uses changes.

4. The study is based on results from the literature on the economics of standardisation and eight case studies. It is important to note that the case studies are hypothetical and do not indicate Ofcom's current, or possible future, policy on the frequency bands considered. The case studies have been considered in isolation, independent of the interaction with other frequency bands, international developments and possible new technologies. They have been developed solely for the purposes of this study and in no way reflect the views, plans or expectations of Ofcom. No inferences should be drawn from their inclusion in this study.

5. The case studies are summarised in Table 1. They describe a baseline and a hypothetical alternative situation. The baseline assumes what actually happened in the case of historic scenarios and a continuation of the current situation in future scenarios. Some case studies consider the effects of relaxing European measures (cases 1-4 and 6 in Table 1) while others consider the effects of introducing measures where none currently apply (cases 5, 7 and 8 in Table 1). Qualitative assessment of costs and benefits is undertaken for all case studies and where suitable data has been obtained the costs and benefits are quantified.

6. In this document we use the following definitions.

   - harmonisation refers to the services as defined in ITU Radio Regulations and CEPT or EC regulations that are permitted in a band, e.g. fixed, mobile, broadcasting, fixed satellite. Harmonisation addresses issues such as band sharing (on a primary or secondary basis) and common designation of bands for particular services in different countries.

   - standardisation refers to the level of specification of each of these services. Standardisation addresses issues such as minimum requirements to avoid the potential for harmful interference (e.g. transmitter power), channelisation (e.g. channel spacings and co-existence parameters such as transmitter power and receiver sensitivity), spectral efficiency (e.g. modulation schemes) and interoperability through the specification of protocols.

Table 1 Summary of Case Studies

	Historic case	Future case
1. GSM 900 &1800 MHz	**Base line** Actual situation **Alternative** Assume spectrum is allocated to mobile at WARC 1979. Assume CEPT recommendations and EC Directives were not put in place. The UK decided to use band for GSM before other countries.	**Base line** Continuation of present situation **Alternative** Assume CEPT and EC measures lapse. The UK seeks to refarm 2G spectrum for 3G in advance of neighbouring countries.
2. TETRA in 854-960 MHz	**Base line** Actual situation **Alternative** Assume CEPT measures are relaxed to allow other standards (e.g. TETRAPOL). Assume CEPT decision on frequency bands for digital trunked services was not implemented.	**Base line** Continuation of present situation **Alternative** Assume CEPT Decision removed. Assume no further standardisation activities on TETRA and both wideband and narrowband systems can be deployed in the available spectrum.
3. BFWA at 2 GHz	Not applicable	**Base line** Band is allocated for use by 3G licence exempt or licensed services **Alternative** Allow use of band for broadband fixed wireless access (BFWA).
4. 32 GHz fixed band	Not applicable	**Base line** Assume the UK follows channel arrangements as given in the ERC Recommendation and other countries implement the Recommendation. **Alternative** Assume the UK implements the ERC Recommendation in part of the band. In the rest of the band assume the UK allows non-compliant systems.
5. PMR at 450-470 MHz	**Base line** Actual situation of non-standard use prevails **Alternative** The UK harmonised the use of the 450-470 MHz band with the rest of Europe in 1980.	**Base line** Assume band only used for narrowband technologies but the band has been realigned with the rest of Europe. **Alternative** Assume the UK allowed the band to be used for wideband as well as narrowband technologies as indicated in ECC Report 25.
6. UHF TV band	Not applicable	**Base line** UK only allows use of DVB-T technology

	Historic case	Future case
		Alternative Assume UK allows use of non-DVB-T mobile technologies in the band and rest of Europe uses DVB-T.
7. Short range devices: radio car keys and telemetry and telecommand systems	**Base line** Non-harmonised use by radio car keys at 418 MHz and telemetry and telecommand systems at 458 MHz. **Alternative** UK followed European harmonisation of bands for radio car keys and telemetery and telecommand systems.	Not applicable
8. PMSE - Video links and wireless microphones	**Base line** Actual situation applies i.e. bands not harmonised **Alternative** There were harmonised bands specifying tuning ranges.	**Base line** Assume current situation of no standards **Alternative** Assume digital standards based on harmonised frequency bands for wireless microphones and video links.

• Economics of Standardisation

7. Harmonisation and standardisation measures constrain the way spectrum may be used and so reduce flexibility in spectrum use. This loss of flexibility may have a cost in terms of foreclosing activities that yield greater economic benefits than the harmonised or standardised use of the spectrum. Against this there may be benefits in terms of greater technical efficiency, international mobility, increased economic activity, increased competition and lower equipment costs.

8. The literature on the economics of standards does not provide any generally applicable theoretical and empirical conclusions. However, it does provide a framework for assessing the costs and benefits of harmonisation and standardisation that we have used in the case studies. Tables 2 and 3 summarise our conclusions on the generic benefits and costs of European harmonisation and standardisation, respectively.

9. Where there is sufficient data we have measured costs and benefits in terms of changes in consumer and producer surplus. In cases where surplus cannot be measured we estimate the impact of harmonisation and standardisation on users' costs as a proxy for the impact on welfare. In situations where there is more/less spectrum available as a result of a change in harmonisation or standardisation this benefit/cost is estimated by multiplying the change in spectrum by an estimate of the opportunity cost of the spectrum. We have not taken account of the benefits or costs arising if government receives more/less licence fee revenue under the scenarios explored.

Table 2 Benefits and costs of European frequency harmonisation

Benefits	Costs
Avoid harmful interference and thereby promote efficient use of spectrum and so increase spectrum use and competition	Restrictions on use (or trade) of underused or unused spectrum for alternative uses
Promote international mobility (of terminals)	Restrictions on ability to refarm spectrum for new services
Reduce equipment costs by reducing number of bands equipment needs to operate in	Insufficient spectrum allocated to some uses
Create large equipment markets	Delays caused by time to agree harmonisation measures
Promote competition between equipment suppliers	

Source: Indepen and Aegis analysis

Table 3 Benefits and costs of European radio equipment standardisation

Benefits	Costs
Avoid harmful interference and promote spectrum efficiency and so increase spectrum use and competition	Restrictions on use of equipment developed elsewhere, which may be cheaper or have greater functionality
Promote international mobility (of terminals)	Less innovation and potential lock-in to an inferior standard
Create large equipment markets	Delays in the introduction of new services and equipment caused by the time to agree standards
Promote competition between equipment suppliers	
Promote interoperability between terminals and public networks (thereby reducing consumer risks)	
Promote competition between service and application suppliers	

Source: Indepen and Aegis analysis

• Case Study Results

10. A summary of the findings from the case studies is given in Table 4. The results depend on the economic and technical characteristics of the services under consideration. General points from the case studies are given in the following paragraphs.

11. In mass consumer markets delay can be very costly since overall consumer and producer surplus is reduced in value for each year of delay by the discount rate. For example, in the 2G historical case, where there are significant economies of scale and international mobility is valued, harmonisation and standardisation were very valuable.

12. In the case studies cross border interference is not a binding constraint on autonomous measures to relax harmonisation and standardisation. Interference can be managed at a cost (by having more lower powered transmitters) or by foregoing benefits (for example, foregoing non-harmonised service in Northern Ireland and parts of the South of England). For example, the UK could relax CEPT standardisation and harmonisation constraints and allow broadband fixed wireless access services in the 2010-2025 MHz band. While interference constraints would increase the costs of providing such services the benefits of greater flexibility are potentially large.

13. There are not always supra-national economies of scale in equipment production (e.g. for PMSE and SRD equipment) and economies of scale may be declining in importance for some services such as fixed links. A case by case analysis of this issue needs to be undertaken.

14. Where spectrum is not expected to be congested, allowing non-compliant services into a band may offer benefits if manufacturers can modify equipment to use the band at low cost. For example, standardisation measures specifying channel plans for the 32 GHz band could be relaxed.

15. Standardisation measures can delay the introduction of services. In the case of TETRA the standardisation process itself took many years and the outcome contained too many options and compromises. As a result, the potential market for digital PAMR was partly eroded by unlicensed private mobile radio and cellular services.

16. Earlier standardisation could have been beneficial in relation to PMR since alignment would have avoided interference costs, fewer users would have been disrupted and valuable spectrum would have been released earlier.

17. Harmonisation would have been beneficial in relation to car key fobs since these devices may travel across national borders, and local interference problems were aggravated by use of non-harmonised spectrum.

18. Non-harmonised use in relation to telemetry in the 458 MHz band has allowed benefits that would have been denied otherwise, as equipment and technical solutions for harmonised spectrum are more expensive and less suitable than those for non-harmonised spectrum.

19. The PMSE case study illustrates that moving from non-harmonised to harmonised frequency allocations can be costly if this reduces the spectrum available for services, scale economies in equipment production are not significant and the benefits of mobility are small (e.g. because equipment has wide tuning ranges).

20. European measures do not always constrain national relaxation of harmonisation and standardisation measures. Domestic requirements are the binding constraint in some

instances. For example, European measures allow standardisation in the 900MHz TETRA band to be relaxed depending on market demand.

21. The PMSE case study also illustrates that harmonised use can impose costs where national patterns of demand are for historical or socio-economic reasons very different from those elsewhere in Europe.

Table 4 Summary of Case Study Findings

	Costs	Benefits	Conclusion
1a. GSM 900 &1800 – historic	Costs of delay in service roll-out: £876-5774m	None	Standardisation and harmonisation had a positive impact.
1b. GSM 900 & 1800 – future	None	Reduced network and operating costs for operators less cost of handset replacement (around £550-900m at 2003 prices), more efficient use of spectrum (a factor of 3) and possible competition stimulus.	Continued requirement for use of 2G standard has no positive effect and may have a negative effect.
2. TETRA	Forgone value from idle spectrum at 900 MHz – could be around £5m/annum.	None, spectrum idle	Standard has net negative effect. Spectrum might be used if other standards were permitted.
3. BFWA at 2 GHz	Forgone use by BFWA – £900-4,400m	Spectrum currently idle but harmonised use of this band could yield benefits for 3G licensed use. Benefits from 3G licence exempt use likely to be small.	Designation for licence exempt 3G use has a negative impact as no standard has been developed and other potential uses are not permitted.
4. 32 GHz fixed services band	Small	Small	Standardisation has a neutral impact.
5a. PMR at 450-470 MHz – historic	See benefits column	Benefits less costs: Earlier harmonisation results in a larger positive NPV. (Difference in NPVs is around £70-100m).	Harmonisation would have yielded greater benefits if undertaken earlier.
5b. PMR at 450-470 MHz – future	No interference costs relative to use of band for narrowband, though issue of guard bands in UK not addressed	Consumer gains from use of wideband.	Benefits from allowing users to chose whether to use wideband or narrowband
6. UHF TV frequencies	Use denied to DTT. Interference impacts minimal.	Use of spectrum by 3G services. Demand is uncertain.	Benefits have small expected value but relaxing harmonisation and standardisation constraints has few costs

	Costs	Benefits	Conclusion
			assuming services can compete on an equal basis for the spectrum. Hence should relax constraints.
7a. Radio car keys	Unquantified costs of moving incumbent users (the military)	£8m-74m – the costs of interference and equipping cars with new key fobs.	Appears to be a good case for harmonisation
7b. Telemetry and telecommand systems	Around £4,000m – costs of using alternative bands and technology	£5m – spectrum released for PMR	Harmonisation would have a substantial negative impact.
8a. PMSE – historic	Costs of moving existing users to harmonised allocation. Not quantified but could be considerable.	At least £2m - PMSE users have to move to another band to make way for the primary use of the band.	Harmonisation could have a negative impact because it would reduce the available spectrum, not lead to lower equipment costs and the benefits of mobility are small. Against this users might gain more security of tenure, though this seems unlikely in practice.
8b. PMSE – future	Inappropriate standard results in idle spectrum in the case of radio microphones	Spectral efficiency gains depend on the standard – positive for video links but not for radio microphones	Standardisation *per se* does not offer benefits.

Source: Indepen and Aegis analysis

• Implications of Technology Change

22. Technology is helping frequency management by making equipment more flexible and increasingly self-adaptive to fit into whatever frequency and interference environment the equipment senses. Economies of scale in relation to the development of flexible equipment may be increasing, because of the high initial costs of software development, however, the costs of adapting this equipment for use in a particular market using particular frequency bands or a particular standard are decreasing. The flexibility affects:

    - Harmonisation in relation to multi-band equipment and flexible tuning ranges
    - Standardisation in relation to software defined radio.

    Developments such as software programmable radio, and radios that sense the radio environment and adapt to it are gradually reducing the need for harmonisation and creating more flexibility, especially for smaller scale applications. Thus for some spectrum bands the balance of costs and benefits is changing in favour of less harmonisation and standardisation.

23. The possibility of flexible equipment raises the question of whether users have incentives to use this equipment. Ofcom could introduce a requirement that licensees should be capable of changing frequency assignments in a relatively short period of time. As there is a risk that this degree of flexibility would be redundant, it may be preferable for Ofcom to indicate that continued use of the band is not guaranteed and that the costs of changing band would not be taken into account in any cost benefit analysis of such a change. This would give licensees an incentive to use flexible equipment. The costs and benefits of such an approach would need to be considered for the particular applications under consideration.

• Conclusions

24. The case studies illustrate that the success or otherwise of European harmonisation and standardisation measures depends on a combination of factors, many of which are difficult to anticipate, and on the specific attributes of the service, technology and frequency bands under consideration. Based on the literature review and the case studies we have undertaken, we find the following factors are important in determining the success of European harmonisation and standardisation measures:

    - Service demand
    - Value of the service
    - Spectral congestion
    - Timeliness and appropriateness of standards
    - Mobility of equipment
    - Economies of scale in equipment production

25. Our general conclusions are as follows.

    - Where spectrum is expected to remain uncongested there are unlikely to be benefits from European standardisation or harmonisation measures that increase the technical efficiency of spectrum use, and there may be costs in terms of foregone use of equipment using alternative specifications.

- Where there are not expected to be supra-national economies of scale, international mobility has low value, and constraints or costs imposed by potential interference are low, European harmonisation measures are likely to offer small benefits and potentially significant costs if harmonisation results in foregone use by higher value services.

- If a change is worthwhile do not wait. In general it is better to act immediately on policy options for which the net present value of the benefits is positive, so as to maximise the net present value of returns. This might not be the case, however, if the costs of change are expected to decrease so that the reduction in costs more than offsets the costs of delaying net benefits.

- For the cases we considered, the existence of European harmonisation measures and the possibility of interference to non-harmonised use of the spectrum in the UK did not impose an unavoidable constraint on UK spectrum use. Harmful international interference can be avoided by altering network configurations, for example, using more base stations operating at lower power and/or by limiting service availability in parts of the UK.

- Decisions over whether to follow CEPT harmonisation measures can be separated from the decision of whether to participate in the development of these measures and the relevant standards in ETSI. Participation in these processes may have benefits in giving a better understanding of the technical issues, the potential of the technology and the views of industry players and should lead to a more informed decision about whether or not to subscribe to CEPT measures.

• Recommendations

26. The recommendations we have developed are given below. They are aimed at increasing the flexibility of the spectrum management regime to respond to unexpected market or technological developments, whilst seeking to retain the main benefits of harmonisation and standardisation measures.

Harmonisation

27. We recommend that the following approaches to relaxing European harmonisation measures are considered.

    - Harmonised bands should allow applications outside the scope of the harmonised service if the services are expected to be compatible in technical terms and there is spare capacity (on a local or a national basis) in such harmonised bands. Within a trading environment this might occur through spectrum leasing.

    - There should be a move away from exclusive harmonisation measures. Rather a half way position where countries would agree to allocate frequencies in a common band for a common purpose, but would also allow other applications to be considered where it can be demonstrated that other applications have a higher value than the harmonised use. Harmonisation could thereby provide sufficient focus and certainty for the achievement of economies of scale in manufacturing, without entirely precluding alternative uses in particular circumstances. Spectrum auctions and/or trading would assist in assigning spectrum to the highest value use under this policy.

- Harmonisation measures should have built-in milestones in relation to market development. Possible milestones are set out in Chapter 4. If the milestones are not met then signatories to CEPT measures could have the option of derogating from the measure.
- If harmonisation measures with milestones are not feasible, then there should be the possibility of time-limited support for European harmonisation and standardisation measures. This would allow countries to opt out of measures after a fixed period of time if the measure was not needed given their national circumstances.

Standardisation

28. We recommend that the following approaches to relaxing European standardisation requirements are considered.

- Adaptive frequency assignment technologies should be used wherever practicable, especially for applications that involve many unrelated users, because they eliminate the safety margin needed for *a priori* planning and the expense of such planning. Use of a specific technology does not need to be required provided that the technologies are not grossly incompatible and that they meet some minimum level of spectral efficiency.
- If adaptive frequency assignment technologies are not appropriate then we recommend that
  - Where independent management is needed because there are many different unrelated users and where there is confidence in large scale demand and congestion is likely, then either a single channelisation and modulation scheme should be specified or a defined spectrum mask and acceptable in band interference levels.
  - Where users can manage their own frequencies in a sub-band, they should be able to choose their own channelisation scheme even if large scale demand and congestion are likely, because they will have sufficient incentives to use the spectrum efficiently.
  - Where independent management is needed because there are many different unrelated users but demand is uncertain and congestion unlikely, then there should be no or minimal constraints on channelisation and modulation within bands.

General changes

29. More generally we recommend that
  - Sunset clauses are built in to European harmonisation and standardisation measures, such that they automatically lapse at some date. This would ensure that redundant regulation does not persist (e.g. measures for GSM) and would give countries the option to reallocate the spectrum in cases where the measure has not been successful (e.g. TETRA at 900 MHz).
  - Harmonisation measures should be justified in advance of being adopted by CEPT by a cost/benefit analysis (undertaken by the CEPT). The cost/benefit analysis should demonstrate that the measure is likely to deliver net benefits to the CEPT countries, based on available information and forecasts.

- There is the possibility of time-limited support for European harmonisation and standardisation measures. This would allow countries to opt out of measures after a fixed period of time if the measure was not needed given their national circumstances or reviews establish there is no evidence of equipment production of actual commercial operations.
- There should be periodic reappraisal of the net benefits to the UK from supporting European harmonisation and standardisation measures, if the measures do not have milestones that allow the UK to remove its support for them.

Role of the regulator versus the market

30. If the regulator collected more market information this could in principle lead to better informed decisions on whether to sign up to European harmonisation and standardisation measures. However, there are limits to the extent to which currently available information and analysis can anticipate future developments. In a number of the case studies (e.g. BFWA at 2GHz and UHF TV) we came to the conclusion that the use of a particular band should be decided by the market – either through trading or auctions that allowed different uses of the spectrum. Where possible we think it is preferable to delegate decisions to the market.

31. One case where market approaches cannot be used to determine the future use of spectrum concerns the choice between allocating spectrum to licence exempt versus licensed uses of spectrum. This choice will need to be informed by market studies and the analysis of the costs and benefits of different uses of the spectrum. To carry out such analyses information on users' willingness to pay for wireless services is required and we suggest that Ofcom undertakes research on this issue.

Categorising spectrum uses

32. Harmonisation and standardisation apply to the applications for which spectrum use is licensed. Consequently any evaluation of harmonisation and standardisation must include an evaluation of the way in which the applications are defined or categorised for the purpose of harmonisation and standardisation. Traditionally bands have been organised according to combinations of application and technology (e.g. GSM for public mobile in one band and TETRA for private trunked mobile in another band). The combination of application and technology has created a "compatibility environment" (i.e. an interference environment)[1] for the band and licensing has been used to divide up the capacity of the band between different users according to different frequency and geographical arrangements (a combination of user, space and frequency).

33. We recommend that Ofcom studies further the relationship of frequency bands to applications to create more flexibility for different applications around the concept of compatibility environments. Some consequences of moving to a more broadly defined compatibility approach include:

[1] The definition of the compatibility environment would include a spectrum mask (which defines permitted power levels for emissions in and out of the band) and an assumed quality of service (e.g. probability of interference). It is likely that other parameters would be also required.

- Applications that are currently treated quite differently but that have similar compatibility characteristics such as mobile and broadcasting (both require exclusive use of frequencies over a given area) would become more readily interchangeable by market means.
- Applications that are less likely to cause or suffer interference could be allowed in compatibility environments that are more demanding, e.g. the use of short range devices in shared frequency bands.
- Spectrum trading would be facilitated.